CONTINUING STUDIES OF PAVEMENT GROOVING IN CALIFORNIA

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ABSTRACT: The development of specifications for pavement grooving projects is presented. The normal groove is 1/8" to 1/4" in depth, cut by a blade 0.095" wide, spaced on 3/4" centers, and cut in the longitudinal direction. Minimum acceptable coverage of the specified pattern is 95%. Water and residue from the cutting operation are picked up by vacuum pumps. A maximum operational noise level of 86dbA is allowed.

Before and after accident studies of pavement grooving projects are presented. Pavement grooving has resulted in a 85% reduction of wet pavement accidents in the grooved areas.

KEY WORDS: Pavement, skidding characteristics, pavement surfaces, grooving, grooving specifications, accidents, accident rates, wear.

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Continuing Studies of Pavement Grooving in California

The use of pavement grooving by the California Division of Highways was reported at the 1968 Western Summer Meeting of the Highway Research Board in Denver. This method of reducing wet pavement accidents has continued to be applied to the problem of the skidding vehicle.

This report relates further developments in pavement grooving in California.

Grooving Patterns

All of our grooving is longitudinal. Grooves are rectangular in form. A minimum depth of 1/8" is required. Depths over 1/4" may produce spalling between cuts. The normal spacing is 3/4" center to center. This spacing may be changed to 1/2" centers or 1" centers for special conditions.

Our earlier grooving projects used a 1/8" wide blade for cutting the grooves. However, there is a tendency for the groove to widen out on small radius curves with high superelevation. As the groove widens the "tracking" effect increases and the grooves are felt by vehicles, particularly motorcycles. In an effort to reduce this effect, a blade of 0.095" width is specified. A report entitled the "Effect of Pavement Grooving on Motorcycle Rideability" has been prepared by the California Division of Highways Materials and Research Department.

Our first grooving contracts required complete coverage of the specified area. Complete coverage is not a practical approach because of surface irregularities and the contractor was allowed a small amount of skipped areas (areas with no grooves whatsoever). This allowance needed definition. It was decided that 95% of any selected 2 foot by 100 foot longitudinal area must be grooved as specified.

Contract Specifications

Grooving on existing highways is done by closing lanes to create a work area and allowing traffic to flow by the operation on unclosed lanes. The residue and water from the cutting machine has to be controlled. If it flows into the traffic lanes it becomes a hazard.

The water and residue are vacuumed up by pumps and stored in water tank trucks and carried away. Our lanes are marked by raised pavement markers and because of the vacuum pick-up devices grooves are not placed within one foot of the lane lines. Therefore, only 10 feet of a 12-foot lane is grooved.

In our metropolitan areas when the daytime traffic demand will not allow lane closures, the grooving work is done at night and during the early morning hours. The contractor usually gets a full eight-hour work shift at night.

The projects are often located in residential areas and noise from the grooving operation must be kept as quiet as possible. We have found that the maximum allowable sound level is 86db on the A scale measured at 50 feet from the side of the machinery. This amount of noise does not generate many complaints from the local residents. The contractors have muffled their equipment and are able to meet this requirement.

Working at night has also required the development of special traffic control devices. We use portable flashing beacons and portable illuminated signs as advanced warning of lane closures. We use illuminated traffic cones for lane control.

The following is an excerpt from our Contract Specifications covering pavement grooving:

GROOVE EXISTING CONCRETE PAVEMENT.--The surface of existing concrete pavement shall be grooved at the locations and to the dimensions shown on the plans. Said grooving shall conform to the requirements of these special provisions.

Grooved areas shall begin and end at lines normal to the pavement center line and shall be centered within the lane width.

Grooving blades shall be 0.095" wide ± 0.003" and shall be spaced 3/4" on centers. The grooves shall be cut not less than 1/8" nor more than 1/4" deep. The grooves on bridge decks shall be cut not less than 1/8" nor more than 3/16" deep.

The actual grooved area of any selected 2-foot by 100-foot longitudinal area of pavement specified to be grooved shall be not less than 95% of the selected area. Any area within the selected area not grooved shall be due only to irregularities in the pavement surface and for no other reason.

Residue from grooving operations shall not be permitted to flow across shoulders or lanes occupied by public traffic or to flow into gutters or other drainage facilities. Solid residue resulting from grooving operations shall be removed from pavement surfaces before such residue is blown by the action of traffic or wind.

The noise level created by the combined grooving operation shall not exceed 86dbA at a distance of 50 feet at right angles to the direction of travel.

Pavement grooving will be measured by the square yard. The quantity of pavement grooving to be paid for will be determined by multiplying the width of the grooved area by the total horizontal length of lane grooved.

The contract price paid per square yard for groove existing concrete pavement shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals and for doing all work involved in grooving the existing concrete pavement, including removing residue, as shown on the plans, as specified in these special provisions, and as directed by the Engineer.

Most of our projects involve grooving approximately 100,000 square yards of pavement surface. Bid prices for grooving have been decreasing during the past few years. In 1966 prices were about $0.90/sq. yd. Early in 1969 with the introduction of the five-foot grooving machine the low bid was $0.75/sq. yd. Later in 1969 the low bids were near $0.65/sq. yd. In 1970 bids as low as $0.50/sq.yd. have been received. For estimating purposes we are using $0.60/sq. yd. The decrease in grooving costs reflects the development of improved equipment for doing the work.

Accident Studies

Four of the six accidents studies presented at the Denver conference are again presented as the study of the effect of grooving continues.

The wet pavement travel and the wet pavement accident rate have been added to the accident summary.

Wet pavement travel is a determination of the number of vehicle miles driven on wet pavement.

An estimate of wet pavement travel (exposure) was made in the following way:

Weather Bureau records from three locations in the Los Angeles area were obtained. The hours showing precipitation of 0.01 inch or more were multiplied by appropriate traffic factors (higher factors for peak periods, lower factors for late night periods) and by the ADT (and length of road grooved) to obtain the "wet pavement MVM" shown on Figures 1-5.* These figures are approximations, subject to adjustment in a study now in progress by the Division of Highways, but the differences in bare (unadjusted) number of wet pavement accidents are so dramatic that any amount of adjustment cannot alter the conclusions.

Of course, it must be remembered that the reason these early jobs were done in the first place is that they had built up concentrations of skidding accidents. Much caution is required in extrapolating the reduction in wet pavement accidents to other locations where such concentrations do not exist.

Case 1

Figure 1 shows the results of grooving on I-5, 50 miles north of Los Angeles. This grooving was completed in 1963 using a 1/8" x 1/8" on 1/2" centers pattern. The ADT on this roadway is 24,000. There were seven wet pavement accidents during the two years before the grooving and none during the seven years after the grooving.

Case 2

Figure 2 shows the results of grooving on I-5 at Laguna Canyon Road near the El Toro Marine Air Station. The grooving was completed in 1966 using the 1/8" x 1/8" on 1/2" centers pattern. The ADT on this roadway is 53,000. The radius of curvature is 2,000 feet. Before skid tests averaged 0.25 with a low of 0.17. After skid tests average 0.30 with a low of 0.27.

* Incidentally, it is estimated that on the average, 2-1/2% of vehicle travel in Los Angeles occurs during hours when precipitation exceeds 0.01 inch. This average is useful in forecasting future wet pavement accidents, but it was <u>not</u> used to calculate wet pavement rates for past performance.

Before grooving there were no wet accidents in 1963, eight wet accidents in 1964 and 47 wet accidents in 1965. For the following four years after the grooving, there were six wet pavement accidents. This study illustrates how rapidly the wet pavement accident problem can develop as traffic wear on the pavement surface causes the friction values to drop from a safe to an unsafe level.

Case 3

Figure 3 shows the before and after accident diagram for 1/8" x 1/8" on 1" centers grooving on I-405 near Bellflower Boulevard in the City of Long Beach. The grooving was done in 1966 and the ADT here is 159,000.

Before skid tests average 0.20 with a low of 0.14. After grooving skid tests averaged 0.24 with a low of 0.17. One and a half years after, the skid tests averaged 0.20 with a low of 0.14. There were 20 wet pavement accidents in the year before grooving and two for the next four years after. This location is on a tangent section of freeway and the skidding started at the sag point where the vehicles start to accelerate as they approach the Bellflower Boulevard Overcrossing. It appears that the skid tests are not well correlated to performance in this case.

Case 4

A broader approach to pavement grooving is shown in Figures 4 and 5 where one mile of the southbound I-405, also in Long Beach, was grooved. There were two curves in the mile, one with a radius of 2,800 feet and 4% superelevation and the other with a radius of 2,500 feet and 6% superelevation. The ADT at this location is 174,000. The grooving was done in 1966 with a 1/8" x 1/8" on 3/4" centers pattern. Before skid tests varied from 0.12 in the right lane to 0.38 in the median lane. After skid tests varied from 0.26 to 0.44 respectively. There were 61 wet pavement accidents during the year before grooving (60% occurring in the two median lanes) and eight accidents in the three years following the grooving. A comparative study of accidents was made on the northbound freeway lanes where there were seven wet pavement accidents in the year before and sixteen the three years after. There was no significant change in the number of dry weather accidents.

Because of the length of the grooved area in Case 4, the accident rates become more meaningful than in the other cases, which were very short sections. The dry pavement accident rate for the grooved area is 1.28 accidents per MVM (million vehicle miles). The wet pavement accident rate for the grooved pavement is 3.48 accidents per MVM.

TABLE I

Location and Type of Pavement	Grooving Pattern	Accidents					
		Before			After		
		No.of Years	Dry	Wet	No.of Years	Dry	Wet
LA-5 78.6/78.9 PCC	1/8"x1/8" on 1/2"	2	2	7	7	32	0
Ora-5 23.3/23.6 PCC	1/8"x1/8" on 1/2"	3	17	55	4	22	6
LA-405 2.1/2.6 PCC	1/8"x1/8" on 1"	1	10	20	4	34	1
LA-405 4.9/6.1 PCC	1/8"x1/8" on 3/4"	1	41	61	3	123	8
LA-101 0.5/0.8 PCC	1/8"x1/8" on 3/4"	1	28	23	2	42	3
LA-5 29.5/30.5 PCC	1/8"x1/8" on 3/4"	1	10	12	3	20	5
LA-101 8.9/9.3 AC	1/4"x1/4" on 1"	1	55	139	3	116	26
LA-101 7.7/8.9(S/B)AC	1/8"x1/8" on 3/4"	2	110	89	1	47	14
LA-10 22.6/22.8 PCC	1/8"x1/8" on 3/4"	1	17	26	4	23	5
LA-10 44.9/45.6 PCC	0.095"x1/8" on 3/4"	2	79	35	1.5	62	3
Ven-101 27.0/27.6 PCC	1/8"x1/8" on 3/4"	3	16	8	2	10	1
Ven-101 29.0/29.7 PCC	1/8"x1/8" on 3/4"	3	20	16	2	9	1
LA-5 75.0/75.5 AC	1/8"x1/8" on 3/4"	3	12	14	1	3	0
Ven-101 10.9/11.2 PCC	1/8"x1/8" on 3/4"	1	3	10	2	8	3
Total		25	420	515	39.5	551	76

Conclusions

Pavement grooving as a correction for wet pavement accidents has been used at many other locations similar to those reported here. In each case, grooving has reduced the number of wet pavement accidents and has continued to be effective.

A summary of 14 studies of pavement grooving locations in the Los Angeles area is shown in Table I. In the before period (one to three years) there were 515 wet pavement accidents; in the after period (one year or more up to seven) there were 76 wet pavement accidents.

Pavement grooving is a solution to the problem of wet pavement accidents caused by skidding on worn pavements. However, the grooving operation interferes with traffic on existing highways and is an additional expenditure of funds. One of our goals is the production of better pavement surfaces with wear resistant qualities.

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